Ecosystem Modeling in Cobscook Bay, Maine: A Collaborative Research Project

Daniel Campbell
Ecologist
U.S. EPA Office of Research and Development (ORD)/National Health and Environmental Effects Research Laboratory (NHEERL)/Atlantic Ecology Division (AED)
(401) 782-3195
campbell.dan@epa.gov

Authors: Daniel E. Campbell[1], Peter F. Larsen[2], David A. Brooks[3], Robert L. Vadas[4], David A. Phinney[2], Brian F. Beal[5]
[1]U.S. EPA ORD/NHEERL/AED
[2]Bigelow Laboratory for the Ocean Sciences
[3]Texas A&M University
[4]University of Maine, Orono
[5]University of Maine, Machias
Keywords: emergy analysis, Cobscook Bay, estuarine ecosystems, hydrodynamic models, primary production

In the mid-1990s, an interdisciplinary, multi-institutional team of scientists was assembled to address basic issues concerning biological productivity and the unique co-occurrence of many unusual ecological features in Cobscook Bay, Maine. Cobscook Bay is a geologically complex macrotidal system (mean tidal range 6 m) located at the mouth of the Bay of Fundy. The strategy adopted by the scientific team was to synthesize known information on Cobscook Bay, focus new field research on basic forcing functions and primary productivity, and organize the information in an energy systems model. The flows of energy and materials through the ecosystem were related to the inflows of physical energy using emergy accounting. As a consequence of this process, new and existing data have been combined and analyzed, and this has led to new ways of thinking about the functioning of macrotidal estuaries. We now recognize the Bay as a naturally eutrophic system, as its high nutrient levels derive from up-welled, nutrient-rich Gulf of Maine waters rather than natural or human activities in the watershed. The largest part of the organizing energy is supplied by tides.

A major thrust of our research into the functioning of the Cobscook Bay ecosystem was the documentation of primary productivity. The principal components investigated were phytoplankton, subtidal benthic microphytes, and four categories of macrophytes (intertidal rockweed, sublittoral fringing kelp, ephemeral red and green algae, and eelgrass). Primary productivity of the Bay, a third of which is exported, is dominated by brown macroalgae and benthic microphytes. Phytoplankton is less productive than expected due to the vigorous mixing regime that limits exposure to light. There is an extraordinary convergence of physical energies in the Bay and, as a result, primary production ranges from moderate to large depending on the requirements for the different kinds of vegetation. However, all plants in the Bay transform the available energy into biomass less efficiently than expected, as indicated by emergy measures, because the emergy available from the tides and waves is in excess. The efficiency of trophic transfers increases as energy moves up the food chain, supporting a productive and diverse fauna in the higher trophic levels. The high diversity found in some environments of Cobscook Bay

(e.g., the intertidal) can be attributed to the extraordinary convergence of natural energies that provide ideal conditions for supporting the development of ecological organization there.

This is an abstract of a proposed presentation and does not represent the official views of the Agency.